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METEOROLOGICAL NEEDS OF THE AVIATION COMMUNITY

By James K. Luers
University of Dayton Research Institute
Dayton, Ohio 45469

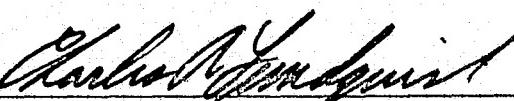
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16. ABSTRACT A study was conducted for the National Aeronautics and Space Administration to determine the important meteorological needs of the aviation community and to recommend research in those areas judged most beneficial. The study was valuable in that it provided a comprehensive list of suspected meteorological deficiencies and ideas for research programs relative to these deficiencies. The list and ideas were generated from contacts with various pilots, air traffic controllers, and meteorologists.			
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FOREWORD

The motivation for the effort presented in this document was to ascertain what the aviation community saw as their most needed new technology relative to enhancing aviation safety. The material covered has been carefully developed with assistance and coordination between the National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS) and the National Transportation Safety Board (NTSB).

This effort was conducted by the University of Dayton Research Institute (UDRI) for the NASA/George C. Marshall Space Flight Center under the technical monitorship of Mr. Dennis Camp of the Aerospace Environment Division, Space Sciences Laboratory. The guidance and assistance received from the technical monitor during the course of this effort is appreciated. The author would also like to express his appreciation to Messrs. John Enders (NASA), Joseph Sowar (FAA), John Connolly (NOAA), Paul Jacobs (NWS), and Alan Brunstein (NTSB) for their comments and suggestions. The support for this effort was provided by Mr. John Enders of the Aeronautics Operating Systems Division, Office of Advance Research and Technology, NASA Headquarters.

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SECTION 1

INTRODUCTION

Weather information is of vital importance to the aviation community. The National Weather Service (NWS) provides to aviation regular observations and forecasts of terminal weather, enroute weather, upper atmospheric winds and temperature, severe weather alerts, and other data. Availability of this data extends to pilots, air traffic controllers, airline meteorologists, flight service station specialists, and other interested parties. In addition, many of the larger airlines employ their own staff of meteorologists to assist in weather forecasting for their specific needs.

In the past decade, improvements have been made in the observation and forecasting of meteorological events. Today, the pilot has a better and more complete understanding of the weather along his flight profile than ever before. The meteorological needs of pilots, however, continually change with the times. Problems which in the past have caused safety hazards and delays for all aircraft such as icing conditions, low clouds, and hail today are problems for only those small aircraft not properly equipped. With each generation of faster, higher flying and better performing aircraft, a new set of meteorological parameters become of prime significance. For example, clear air turbulence, low level wind shear, high surface temperatures, and upper air temperature profiles, are of more critical importance for today's jet than for earlier low flying aircraft. Future aircraft and aerospace vehicles such as the supersonic transport, VSTOL aircraft and the Space Shuttle promise to shift emphasis again toward a new set of atmospheric parameters for which the performance of these aerospace vehicles is most sensitive.

Because of the continual changes of meteorological needs and the improved observational data that is available to aviation, periodic evaluations must be made to assure that present needs are being met and that satisfactory research programs are in progress to satisfy future requirements.

The objective of this study is to determine for the National Aeronautics and Space Administration (NASA) the important meteorological problems that influence aviation safety and to recommend research in those areas judged most beneficial. The proposed study consisted of four tasks: a) the design of a questionnaire to solicit the meteorological needs of all segments of the aviation community, including private, corporate, charter and airline pilots, approach, tower and enroute air traffic controllers, flight service station specialists, and airline meteorologists; b) analysis of the questionnaire to identify and rank their meteorological needs; c) identification of ongoing research efforts that may have a positive impact towards solution of these needs; d) recommend to the NASA a priority list of fertile areas of environmental research, not presently receiving adequate attention, which promise to enhance aviation safety.

The four tasks of the study as described above were not completed since the questionnaire was not approved by the Office of Management and Budget (OMB). Only Task (a) was completed. Nevertheless the study was valuable in that it provided a comprehensive list of, what at least some aviation personnel considered, meteorological deficiencies. It also provided suggestions for alleviating these deficiencies.

The following sections detail the work performed on task (a), design of the questionnaire. In addition, a few statements concerning the proposed tasks (b), (c), and (d) are documented for future reference.

SECTION 2
DESIGN OF QUESTIONNAIRE

To provide background information concerning the nature and importance of meteorological information to the aviation community local visits were made to pilots, air traffic controllers, flight service station personnel and meteorologists. The interviews were designed to determine the present and future meteorological needs of each group and how these needs are presently being met, deficiencies in meeting these needs, and suggestions or ideas for enhancing the quantity and quality of meteorological data presently being provided to the aviation community. Discussions were held with the following local groups.

Pilots

Private/Charter (Aviation Sales Incorporated)
Corporate Pilots (National Cash Register)
Airline Pilot (United Airlines)

Controllers

Tower (Dayton Municipal Airport, Cincinnati Lunken Airport)
Approach (Dayton RAPCON)
En Route (Indianapolis Regional Control Center)

Flight Service Station Personnel

Dayton Municipal Airport
Cincinnati Lunken Airport

Airline Meteorologist

United Airlines

The basic question asked of all personnel interviewed was, "In your opinion what type of meteorological information which you presently are not receiving would be of value to you with regard to aircraft safety?"

Discussions with the above personnel proved very instructive. Information concerning unique problems at specific airports as well as overall deficiencies in meteorological data was obtained. In addition,

several original ideas concerning presently unavailable data were generated. A summary of the significant points of discussion with each of the above personnel is contained in Appendix 1. As a result of these discussions, a preliminary set of questions, ideas and suggestions was generated to serve as a guide in soliciting responses from other individuals. The local interviews also substantiated the need for visiting other regions of the country. Problems of critical concern at Cincinnati Lunken Airport, for example, such as fog settling in the valley between the Ohio and Miami rivers would not be expected to be a serious problem at most other airports. Thus, the need to visit regions of the country with peculiar weather or terrain patterns became even more apparent. Restricting the regional visits to the continental United States, the following cities were chosen because of their anticipated regional effects: Western Sea Coast - Los Angeles; Eastern Sea Coast - Boston; Great Plains - Oklahoma City; Western Mountain Region - Denver; Eastern Mountain Region - Knoxville; and Northwest - Seattle. At each city an attempt was made to interview each type pilot as well as the various types of traffic controllers. At most cities, interviews with each of these type individuals were achieved. Responses from the various individuals described the meteorological problems and needs of that section of the country. For example, the more serious problems found in the above regions were: Denver - thunderstorms and rapidly changing wind profiles; Seattle - icing and warm air fog; Knoxville - low clouds and poor visibility in the mountains; Oklahoma City - rapid changing of the weather; Boston - wind shear and sea fog; and Los Angeles - carburetor icing.

After reviewing all the individual responses from both the regional and the local interviews, a preliminary questionnaire was generated. The questionnaire was intended to be as general as possible taking into consideration all items that could be considered relevant to aviation safety. The questionnaire was so worded as to suggest types of meteorological data that may be beneficial, such as: wind shear, wake turbulence, slant visual

range, cloud cover and height, onboard turbulence sensors, satellite photographs, etc. No attempt was made to include or exclude questions based upon judgement of the practicability of an idea.

The preliminary questionnaire was submitted to NASA for approval and/or modifications. NASA in turn distributed copies of the questionnaire to interested persons of the FAA, NOAA, NWS, and NTSB. Critical review and constructive suggestions from individuals of these agencies greatly enhanced the questionnaire. The final version of each of the four questionnaires is contained in Appendix 2.

Approval for the general distribution of the questionnaire was not obtained from the Office of Management and Budget. Thus, the effort was terminated.

SECTION 3

DISSEMINATION AND ANALYSIS

Planned dissemination for the questionnaire was as follows. For each category; pilots, tower and approach controllers, enroute controllers and flight service station specialists, a group of people would be selected from various regions of the country representing different geographic and climatic conditions. For example, approximately 300 pilots would be chosen from the ranks of private, corporate, charter, and airline pilots. Their flying experience would reflect the diverse weather and terrain conditions prevalent throughout the U.S. Names of persons to whom questionnaires were to be sent would be solicited from organizations such as the FAA, NWS, Aircraft Owners and Pilots Association (AOPA), Airline Pilots Association (ALPA), Air Traffic Controllers Association (ATCA), National Business Aircraft Association (NBAA), and other sources. Responses would also be directly solicited from these professional organizations.

Evaluation of the questionnaire would be based directly upon the responses. The determining factor in evaluating a response would be the usefulness of a given piece of meteorological data in assisting a pilot, controller, or FSS specialist in performing his job and how this data would result in enhanced aviation safety. To clarify opinions expressed on questionnaires, follow-up telephone conversations could be useful. In addition telephone conversations with knowledgeable third parties may prove beneficial in assessing the validity of specific questionnaire responses. The results of the evaluation would be a ranked list of meteorological needs for each segment of aviation: pilots, tower and approach controllers, enroute controllers and flight service station specialists. The ranking would be according to severity of need, and anticipated impact on aviation safety.

SECTION 4

TYPE OF ONGOING RESEARCH EFFORTS

Task (c) of the proposed program was to determine ongoing and planned research programs sponsored by both governmental and private enterprise and to assess their influence and potential for solving the problems specified in the ranked lists of meteorological needs for the aviation community. Discussions would be held with personnel from agencies such as NASA-Goddard, National Environmental Satellite Service (NESS), NOAA, the Wave Propagation Laboratory, National Severe Storms Laboratories (NSSL), FAA, weather radar manufacturers, National Center for Atmospheric Research (NCAR), U.S. Air Force Geophysics Research Laboratories, aircraft manufacturers, and other research organizations. As a result of the study of ongoing research efforts, task (d) a re-ranking of the lists of meteorological needs would be made relevant to both the severity of the need and the adequacy of ongoing and planned research in satisfying this need. The final list would be a set of recommendations to NASA concerning beneficial areas of research in the coming decade that promised to have significant influence on improved aviation safety.

SECTION 5
SUMMARY AND CONCLUSIONS

Although the program was not completed as originally intended, much valuable information resulted from this study. A review of the responses shown in the Appendix and the four questionnaires themselves will reveal the comprehensiveness of the study. Many worthwhile ideas for research programs can be gleaned from this study. What is lacking is an evaluation of the ideas presented by those interviewed. Excessive subjectivity would be required to generate a ranked list of meteorological needs for different segments of aviation from the present results of this program. For that reason, suggestions and recommendations to NASA relative to beneficial research programs cannot be made at this time. It is hoped that in the future the questionnaire can be distributed, results analyzed, and recommendations made to NASA concerning research areas that will benefit aviation by satisfying the meteorological needs of various segments of the aviation community.

APPENDIX 1

SUMMARY OF DISCUSSIONS WITH AVIATION PERSONNEL

Instrument Pilot - Small Aircraft

1) Thunderstorms

- : Need knowledge of interior of thunderstorm
- : Areas of hail and large amounts of precipitation
- : Top of thunderstorm would be valuable
- : Method of distinguishing between heavy rain and hail needed.

2) Forecasts

- : Forecasts are very bad
- : Winds aloft are terrible
- : Forecast of type of icing (clear or rime) would be valuable

3) Turbulence

- : Occurrence and height of the haze (pollution) layer very important generally east of major cities - 3000 feet to 10-12,000 feet
 - brown tint - lots of dust particles - unstable air - light turbulence
 - clear day - after passage of cold front
- : Any information about wake turbulence desirable - particularly at fields with parallel runways

4) Visibility - Clouds

- : Cloud tops - Important because of icing
- : Airborn visibility - not needed
- : SVR - very desirable

5) Wind Shear

- : Have not experienced serious wind shear problems
- : Trees and buildings can cause shear problems

6) Runway Condition

- : Hydroplaning not a problem since no braking on light aircraft
- : Ice on runway is problem with short runways

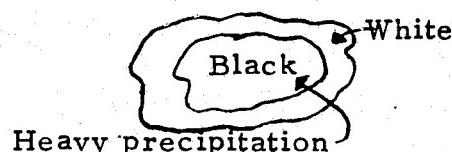
Corporate Pilots

National Cash Register Co.

Grumman Gulfstream Aircraft

1) Thunderstorms

- : -5°C to +10°C worst for lightning
- : Lower Altitude - More turbulence (usually)
- : Higher Altitude - Hail and Icing
- : Need better knowledge of interior of thunderstorm
- : Airborne radar not adequate



if black area approaches
white area → strong
shear and turbulence

- : Need to know areas of heavy precipitation, turbulence, icing, lightning
- : Need to know what punishment A/C can withstand
- : Top of thunderstorm would be very valuable

2) Forecasts

- : Winds aloft are very bad (they are very important for West Coast flights)
- : Jet stream is not correct or valid
- : Weather forecasts are no better and in some respects worse than during WWII (NCR interprets own weather)
- : Airlines have winds aloft data but will not disseminate
- : Best forecasting is done by airlines (by far)
- : Better short term forecast of onset and dissipation of 0-0 visibility needed
- : Better knowledge of local effects, e.g., Why Dayton fogged in and not, Springfield, Columbus, etc.

3) Turbulence

- : Any information about CAT would be valuable
- : Any information about wake turbulence very valuable
- : Wake turbulence can be bad with dual runway and crosswinds
- : Wake turbulence may be bad on approach e.g., 1000 feet
- : NCR pilots have had several severe encounters with wake turbulence
- : Wake turbulence is more persistent in light winds

4) Visibility

- : SVR not too important for NCR pilots
- : Airborne visibility is not too important
- : Top of cloud layer is known sufficiently by onboard radar
- : Effect of snow intensity on visibility could be desirable

5) Others

- : Procedure for explosive decompression of aircraft (at 40,000 feet you have 15 sec. to get oxygen.)
- : Many corporates fly above 40,000 feet

6) Wind Shear

- : Trees and buildings can cause shear problems at certain runways
- : Very stable shears not experienced by NCR pilots

7) Runway Conditions

- : Hydroplaning can be a problem

Airline Pilot

United Airlines

1) Thunderstorms

- : Jets generally get above thunderstorms - not too much of a problem except approach and climbout

2) Forecasts

- : Does not believe turbulence forecasts - two ways of getting turbulence - watch contrail of preceding aircraft and listen on radio for reports from aircraft in vicinity

3) Turbulence

- : Wake turbulence not too worried about - most landing (75% in crosswinds at O'Hare) in cross winds so wake turbulence is off runway
- : Onboard turbulence sensor would be valuable

4) Visibility

- : SVR not needed
- : Ceiling at middle marked is desirable

5) Wind Shear

- : Wind shear can be problem - detector would be nice

6) Runway

- : Need to know braking action - good - fair - poor on runway at time of touchdown by 1/3 segments of runway

7) Others

- : Need very accurate temperature and winds en route or for flight planning - performance of aircraft highly sensitive to temperature - If accurate temperature and winds known at flight time then flight plan will be good and no deviations necessary - If not, temperature needed to change flight plan en route - temperature accurate to ± 3 degrees

Tower Control

Dayton Municipal Airport

1) Thunderstorms

- : Monitoring of activity in immediate vicinity of airport needed
- : Network of sensors for 10 mile vicinity around airport suggested solution
- : Direction and motion - size - amount of hail - turbulence in thunderstorm would be very useful
- : Need tops of thunderstorms
- : Ability to know when icing condition exist

2) Forecasts

- : Icing forecasts needed
- : Present forecasts are not good for Dayton Airport
- : Short term forecast of onset and dissipation of 0-0 visibility needed

3) Turbulence

- : Wake turbulence is very important - little knowledge available

4) Visibility - Cloud

- : Airborne visibility may be of value
- : Cloud tops important because of winter time icing
- : SVR useful

5) Wind Shear

- : Large shears not experienced at Dayton

6) Runway Conditions

- : Runway condition important for braking
- : Wind conditions at end of runway desirable
- : Summertime runway temperature desirable

7) Others

- : General pictorial display of all weather in 10-15 mile vicinity of airport would be super

Approach Control

Dayton RAPCON (Wright Patterson Air Force Base)

1) Thunderstorms

- : Cannot determine severity of storm with respect to turbulence by radar
- : Turbulence is more important than precipitation
- : Need to know (measure) conditions that cause icing
- : Snow not easily delineated by radar - snow has little adverse effects on aircraft or pilot

2) Forecasts

- : Fog forecasting very important - 0-0 visibility onset and dissipation
- : Not involved with other forecasts

3) Turbulence

- : If turbulence known to exist divert aircraft below layer if possible

Flight Service Station and Tower Controllers

LUNKEN AIRPORT (Cincinnati)

1) Thunderstorms

- : Intensity and immediacy are the critical problems with thunderstorms.
- : Icing not too important

2) Turbulence

- : Turbulence in approach zone would be nice but not necessary
- : Wind shear at touchdown is not a problem at Lunken
- : Wind shear from buildings and trees is not a serious problem
- : Wake turbulence is not a serious problem since no big aircraft use Lunken

3) Visibility

- : Fog is a very serious problem due to airport location in valley between Miami and Ohio rivers
- : Lunken is fogged in nearly every morning in fall and spring
- : Lunken has fog layer from approximately 400-700 feet. Would be very good if height and thickness of layer were known.
- : 30 minutes advance warning of when fog will lift would be of utmost benefit
- : SVR not important. Vertical visibility nearly always greater than slant.
- : Cloud tops very important
- : Cloud thickness very important area wise
- : Depth between cloud layers very important
- : Low altitude (below 10,000 ft) is much more important than high altitude

4) Forecasts

- : Winds aloft not too bad (10-15 knots accuracy)
- : NWS gives too general a forecast for upper air winds
- : Forecasts in general are not too good
- : Lots of CAT prognostication but very few verified reports

5) Others

- : FSS has antiquated equipment that requires lots of manual work to assimilate and interpret weather charts; number one problem. Solution would be a CRT display of pertinent weather information with instant access to all sections of the country.

Flight Service Station

Dayton Municipal Airport

FSS is middle man - not directly involved in using meteorological data

- : Better prediction of thunderstorms needed**
- : Improvement in forecasts needed**
- : Better turbulence data needed**
- : Better knowledge of thunderstorm activity and height of top of clouds**

En Route Control (Indianapolis Region)

1) Thunderstorms

- : Altitude of thunderstorm would be valuable (some available radars have this capability)
- : Freezing rain cannot be distinguished from ordinary rain
- : Radar often paints temperature inversion as storm activity
- : Need to know where turbulence is inside thunderstorm
- : Need to know icing areas in thunderstorm
- : Distinction between rime and clear icing not important

2) Forecasts

- : Not used extensively by controllers - pass on forecasts if requested

3) Turbulence

- : Wake turbulence not a serious problem if separation is maintained

4) Visibility

- : Cloud heights and thickness of layer would be nice
- : Ceiling would be valuable - presently available only at weather stations
- : Fog is problem for take off and landing at small airports
- : Cloud tops presently available only from pilot reports

5) Others

- : Upper air winds not needed
- : Radar that can identify an aircraft in a storm - broad band radar cannot pick up aircraft: perhaps reverse aircraft image from positive to negative
- : Controllers are too busy maintaining separation to get too involved with weather

Airline Meteorologist

United Airlines

1) Thunderstorms

- : Need to know location of turbulence in thunderstorms
- : Vortices from squall line (flank) often have turbulence - non detectable
- : Tops of thunderstorms available NWS - fairly accurate - can go above or around most
- : Higher the altitude the less effective is airborne aircraft to stay 20 miles from heavy precipitation
- : Icing not a problem - deicing equipment

2) Forecasts

- : Use NWS upper air winds but revise based on honker flights by U.A. and other airline flights
- : Need accurate forecast of onset and termination of freezing rain and heavy snow at terminals
- : Need accurate forecast of onset and dissipation of fog at airports

3) Turbulence

- : Airborne turbulence detector would be very valuable
- : Ground turbulence detector for vicinity of airport also valuable for approach and climb out
- : Better location of jet stream valuable - obtained presently from INS honker flights
- : Airport wake turbulence detector would be valuable
- : Mid-air wake turbulence detector has some value

4) Visibility

- : Do not need SVR-RVR satisfactory

5) Windshear

- : Low level detector at airport would be valuable - especially at Marine Airports

6) Fog

- : Must know more about physics of fog so that we can predict its onset and dissipation
- : Fog sensing a very economically important problem
- : Fog dissemination technique presently in operation at \approx 10 airports

Airline Meteorologists (United)

7) Others

- : Runway temperature important to flight planning but is measured okay
- : Data link needed between aircraft and ground so that meteorological input is instantaneously and automatically updated
- : Icing of parked aircraft very important - deicing is very costly - fly planes out if freezing rain expected
- : Lightning or electrostatic discharge is a nuisance but is not an important problem

APPENDIX 2
QUESTIONNAIRES

PILOTS

PILOTS

The National Aeronautics and Space Administration (NASA) and its predecessor, the National Advisory Committee for Aeronautics (NACA) has long served as the U.S. governments' primary source of advanced technology for aeronautical and space activities. Present aeronautical research activities of NASA include a broad program of new technology development to enhance aviation safety. Included in this program are several individual research projects related to the meteorological aspects of aviation safety. These projects explore advanced measurement and analysis concepts which offer the potential for improved design optimization of aircraft, control systems, ground and airborne instrumentation and their sensors, by NOAA, NWS, FAA, and the commercial manufacturers. To assist NASA in conducting research that is responsive to the most pressing needs for new technology the University of Dayton Research Institute (UDRI) is conducting a study for NASA intended to provide a better focus on future technology needs in this area. The enclosed questionnaire has been carefully developed with assistance from FAA, NOAA, and NTSB and is intended solely to define required technology improvements; not to be a critical evaluation of present meteorological information collection and dissemination procedures. Candid suggestions that could potentially result in improved aviation safety through the development of new natural environment technology are welcomed.

The UDRI is soliciting and reviewing relevant ideas from a wide spectrum of the aviation community: airline, charter, corporate, and private pilots; en route, approach, and tower controllers; airline meteorologists; FSS personnel; and professional associations.

The attached list of questions was generated through discussions with people from a wide cross section of the aeronautical community including pilots, FAA personnel, NWS personnel and meteorologists. In responding to these questions, we would ask that you specify the

reason for your answer and the use to which you would put the data. Since a statistical compilation of the results is NOT the objective of this questionnaire, the mere frequency of a given response is of little importance. Rather, what is important is a discussion of the use and need of each type of information so that its importance relative to aviation safety and performance can be evaluated. We ask you to keep in mind that aviation accidents are often associated with severe or unusual weather conditions. Though the frequency of occurrence of these events may be seldom, the potential for improved aviation safety under these conditions could be significant if appropriate technology were available.

In responding to this questionnaire, we ask that you answer the questions in relation to how it affects you without speculation concerning the desires of other persons involved (such as pilots, traffic controllers, etc.). Similar questionnaires are being sent to other members of the aviation community. Each topic within the questionnaire is concluded with a blank space for additional comments. We welcome here any further discussions of problems which you feel were inadequately presented, or perhaps other ideas or concepts that you feel are pertinent.

A follow-up telephone interview will be made with selected respondees of this questionnaire. The purpose of the follow-up will be to solicit additional information and/or clarification concerning responses that are deemed especially noteworthy. For this reason, we request you sign your name, give your telephone number and a brief description of your experience. No individual names of respondees will be included in any published document without the consent of the individual.

Thank you for your cooperation.

James K. Luers

University of Dayton
Research Institute
(513) 229-3921

BIOGRAPHY

In analyzing your response to this questionnaire, some background information is necessary. This information will be useful to us in determining the types of pilots and aircraft that experience the problems discussed in the questionnaires. We request you sign your name and telephone number so we can get in contact with you should any clarification be necessary. Please indicate if you would like to receive a copy of the report resulting from this study and whether or not you object to your name appearing in such a report.

NAME _____

MAILING ADDRESS _____

TELEPHONE _____

TYPE OF LICENSE(S) _____

Type of aircraft generally flown over the past three years:

Frequency of flying in past three years _____

EXPERIENCE:

Type of Aircraft	Flying Hours
------------------	--------------

Jet	_____
-----	-------

Prop	_____
------	-------

Helicopter	_____
------------	-------

Type of Flying

Military

Airline

Cargo

Corporate

Charter

Private

Flying Hours

Would you like to receive a copy of the report resulting from
this study? _____

Can your name be included in such a report? _____

THUNDERSTORM ACTIVITY

1. The location of turbulence within and around a thunderstorm
2. The tops of the clouds above a thunderstorm cell
3. The areas of icing within a thunderstorm
4. The areas within a thunderstorm where lightning is most likely to occur
5. The ability to distinguish between heavy rain and hail by on-board weather radar
6. The ability to determine shape of clouds by on-board weather radar when flying above clouds
7. An up-to-the-minute account of present thunderstorm activity along an air route; its direction, speed, and severity

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate (3) Slight Problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

THUNDERSTORM ACTIVITY

8. An up-to-the-minute account of present thunderstorm activity within a 15-mile radius of any airport; its direction, speed, and severity
9. A 15-30 minute advance projection of incoming thunderstorm activity within a 15-mile radius of airport

ADDITIONAL SUGGESTIONS

	Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate (3) Slight Problem to me?	Describe <u>when</u> and <u>how</u> you would use this information if it were available to you (please comment on all serious problems and others as appropriate).
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TURBULENCE AND WIND

1. Precise location of clear air turbulence along an air route
2. Location of turbulence in approach and climb-out zones
3. Location and persistence of wake turbulence in vicinity of runways
4. Location of wake turbulence in approach and climb-out zones
5. Location of wake turbulence along an air route
6. Location and severity of wind shear in approach and climb-out zones
7. Location and severity of wind shear caused by local factors such as wind flowing over and around trees, buildings, and other structures.
8. Location of and wind speed in jet stream

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate or (3) Slight problem to me?

Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

TURBULENCE AND WIND

9. Upper air winds (above 10,000 ft.) by altitude along any air route

10. Low level winds (below 10,000 ft.) by altitude for a specified area

11. Surface winds at various locations in the mountains, e.g., at passes, along ridges, etc.

12. Location and intensity of mountain wave turbulence

13. Winds and altimeter setting at airports where no observations are presently taken

ADDITIONAL SUGGESTIONS

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate or (3) Slight problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

CLOUDS, VISIBILITY, FOG

1. Cloud base along an air route for a given area or in vicinity of airport
2. Tops of each layer of clouds along an air route for a given area or in vicinity of airport
3. Enroute visibility along an air route or for a specified region
4. Visibility in area where snow is occurring (i. e., degradation of visibility resulting from snow)
5. Cloud base at various locations in mountains, e.g. passes, ridges, etc.
6. Location and height of haze (pollution) layer
7. Slant visual range (SVR) along the glide slope
8. Ceiling at the middle marker
9. 15-30 minute reliable advance notice of onset of fog at an airport; i. e., airport goes below minimums

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

CLOUDS, VISIBILITY, FOG

10. Reliable estimate of length of time airport will be below minimums
11. Visibility, cloud cover, and ceiling at airports where no observations are presently made

ADDITIONAL SUGGESTIONS

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).
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RUNWAY

1. The amount and location of ice and slush on the runway
2. Braking conditions of runway by segments (e.g., first 1/3, middle 1/3, last 1/3)
3. When conditions are conducive to hydroplaning for your aircraft
4. Temperature at ends of runway

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate or (3) Slight Problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

ADDITIONAL SUGGESTIONS

OTHERS

1. 15-30 minute advance notice of freezing rain, or heavy snow at an airport (icing of parked aircraft)
2. Altitude at which snow changes to rain
3. Accurate temperature at any altitude along an air route
4. Temperature inversion in approach or climb-out zone
5. Up-to-the-minute weather information in preflight briefing; e.g., present location of thunderstorms.
6. In-flight availability of up-to-the-minute weather conditions for any region of the country, e.g., hail, thunderstorm activity, visibility, etc.
7. Automatic transmitting to you for any given area all Airmets, Sigmets and pilot reports within 15 minutes of the time the report is made
8. Areas where icing conditions exist and type of icing (rime or clear)

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight problem to me?

Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

ADDITIONAL SUGGESTIONS

FORECASTS

We are not attempting here to criticize present forecasting techniques, accuracy, etc. What we would like to know is what type of forecasts you need, how you will use them, and what forecast accuracy is required so that the forecast will significantly influence your decision-making process. Obviously, 100% forecasting accuracy is wanted by everyone. Even more obvious is that it is unachievable. In a practical sense, it is clear that the longer in advance the forecast is, the less accurate it will be. In presenting the questions in the format below, we are attempting to discover what types of forecasts hold the greatest potential for improved decision making.

FORECASTS

1. Forecast of freezing rain, hail, or heavy snow at an airport
2. Forecast of onset of fog (i.e., airport going below minimums)
 - a) destination airport
 - b) departure airport
3. Forecast of duration of fog and/or time when airport goes above minimums
 - a) destination airport
 - b) departure airport

	<p>What decision(s) that you make would be influenced by this forecast? Additional comments?</p>	How long of an advanced forecast is needed?	The forecast must be essentially accurate what percent of the time to be influential in your decision making?
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FORECASTS

4. Cloud cover, precipitation, visibility forecast at an airport
 - a) destination airport
 - b) departure airport

5. Forecast of wind shear in approach or climb out zone

6. Forecast of upper air temperatures by region and altitude

7. Clear air and other types of turbulence forecasts by region and altitude

8. Forecast of regions where icing conditions exist

9. Forecasts of type of icing (rime or clear)

10. Forecasts of severe enroute weather

11. Forecast of upper air winds > 10,000 ft.

12. Forecast of low level winds 0 - 10,000 ft.

	<p>What decision(s) that you make would be influenced by this forecast?</p> <p>Additional comments?</p>	<p>How long of an advanced forecast is needed?</p>	
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			<p>The forecast must be essentially accurate what percent of the time to be influential in your decision making?</p>
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FORECASTS

13. Jet stream forecast (its location and speed)

14. Forecasts of mountain wave activity

OTHERS (Specify)

What decision(s) that you make would be influenced by this forecast?

Additional comments?

How long of an advanced forecast is needed?

The forecast must be essential accurate what percent of the time to be influential in your decision making?

INSTRUMENTATION

1. An on-board sensor that observes areas of CAT ahead of the aircraft

2. On-board instrument used when in turbulence to determine best path out of turbulence

3. An on-board sensor that measures visibility in any direction

4. An on-board instrument that pictorially displays any type of weather information requested

5. An on-board instrument that automatically notifies pilot of significant weather at airport when he tunes into an appropriate navigational aid such as ILS (e.g., wind shear, slush on runway, etc.)

6. Inexpensive detector that warns of carburetor icing

7. Airborne wind shear detector

ADDITIONAL SUGGESTIONS

<p>Would this sensor be of use to you? (Yes/No)</p>	<p>Would it provide the data needed to solve one of your (1) serious, (2) moderate, (3) slight problems.</p>	<p>What are the requirements for the sensor to be useful; e.g., cost, size, reliability? (Specify values if possible).</p>	
			<p>Comment about how the sensor would influence your performance.</p>

TOWER AND APPROACH CONTROLLERS

TOWER AND APPROACH CONTROLLERS

The National Aeronautics and Space Administration (NASA) and its predecessor, the National Advisory Committee for Aeronautics (NACA) has long served as the U.S. governments' primary source of advanced technology for aeronautical and space activities. Present aeronautical research activities of NASA include a broad program of new technology development to enhance aviation safety. Included in this program are several individual research projects related to the meteorological aspects of aviation safety. These projects explore advanced measurement and analysis concepts which offer the potential for improved design optimization of aircraft, control systems, ground and airborne instrumentation and their sensors, by NOAA, NWS, FAA, and the commercial manufacturers. To assist NASA in conducting research that is responsive to the most pressing needs for new technology the University of Dayton Research Institute (UDRI) is conducting a study for NASA intended to provide a better focus on future technology needs in this area. The enclosed questionnaire has been carefully developed with assistance from FAA, NOAA, and NTSB and is intended solely to define required technology improvements; not to be a critical evaluation of present meteorological information collection and dissemination procedures. Candid suggestions that could potentially result in improved aviation safety through the development of new natural environment technology are welcomed.

The UDRI is soliciting and reviewing relevant ideas from a wide spectrum of the aviation community: airline, charter, corporate, and private pilots; en route, approach, and tower controllers; airline meteorologists; FSS personnel; and professional associations.

The attached list of questions was generated through discussions with people from a wide cross section of the aeronautical community including pilots, FAA personnel, NWS personnel and meteorologists. In responding to these questions, we would ask that you specify the

reason for your answer and the use to which you would put the data. Since a statistical compilation of the results is NOT the objective of this questionnaire, the mere frequency of a given response is of little importance. Rather, what is important is a discussion of the use and need of each type of information so that its importance relative to aviation safety and performance can be evaluated. We ask you to keep in mind that aviation accidents are often associated with severe or unusual weather conditions. Though the frequency of occurrence of these events may be seldom, the potential for improved aviation safety under these conditions could be significant if appropriate technology were available.

In responding to this questionnaire, we ask that you answer the questions in relation to how it affects you without speculation concerning the desires of other persons involved (such as pilots, traffic controllers, etc.). Similar questionnaires are being sent to other members of the aviation community. Each topic within the questionnaire is concluded with a blank space for additional comments. We welcome here any further discussions of problems which you feel were inadequately presented, or perhaps other ideas or concepts that you feel are pertinent.

A follow-up telephone interview will be made with selected respondents of this questionnaire. The purpose of the follow-up will be to solicit additional information and/or clarification concerning responses that are deemed especially noteworthy. For this reason, we request you sign your name, give your telephone number and a brief description of your experience. No individual names of respondents will be included in any published document without the consent of the individual.

Thank you for your cooperation.

James K. Luers

University of Dayton
Research Institute
(513) 229-3921

BIOGRAPHY

In analyzing your response to this questionnaire, some background information is necessary. This information will be useful to us in analyzing the results from this questionnaire. We request you give your name and telephone number so we can get in contact with you should any clarification be necessary. Please indicate if you would like to receive a copy of the report resulting from this study and whether or not you object to your name appearing in such a report.

NAME _____

ADDRESS _____

TELEPHONE _____

TRAINING _____

EXPERIENCE _____

Tower Controller Years _____

Approach Controller Years _____

RADAR EXPERIENCE YEARS

(Specify types of Radar; e.g., weather radar, ground control, etc.)

PILOT'S LICENSE(S) _____

FLYING EXPERIENCE

Type Aircraft Flying Hours

Jet _____

Prop _____

Helicopter _____

Would you like to receive a copy of the report resulting from this study? _____

Can your name be included in such a report? _____

THUNDERSTORM ACTIVITY

1. The location of turbulence associated with a thunderstorm in vicinity of airport
2. The tops of the clouds above a thunderstorm cell in vicinity of airport
3. The areas of icing within a thunder- in vicinity of airport
4. The ability to distinguish between, heavy rain and hail by weather radar
5. An up-to-the-minute account of present thunderstorm activity within a 15-mile radius of airport; its direction, speed and severity
6. A 15-30 minute advance projection of incoming thunderstorm activity within 15-mile radius of airport

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight problem to me?	Describe <u>when</u> and <u>how</u> you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

ADDITIONAL SUGGESTIONS

TURBULENCE AND WIND

1. Location of turbulence in approach and climb-out zones
2. Location and persistence of wake turbulence in vicinity of runways
3. Location of wake turbulence in approach and climb-out zones
4. Location and severity of wind shear in approach and climb-out zones
5. Location and severity of wind shear caused by local factors such as wind flowing over and around trees, buildings, and other structures in vicinity of airport
6. 15-30 minute advance warning of a change in wind direction in vicinity of airport
7. Low level winds by altitude in vicinity of airport
8. Winds and altimeter setting at satellite airports where no observations are presently made

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight problem to me?

Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

ADDITIONAL SUGGESTIONS

CLOUDS, VISIBILITY, FOG

1. Cloud base at various locations in vicinity of airport
2. Tops of each layer of clouds in vicinity of airport
3. Visibility in area where snow is occurring (i. e., degradation of visibility resulting from snow)
4. Location and height of haze (pollution layer)
5. Slant Visual Range (SVR) along the glide slope
6. Ceiling at the middle marker
7. 15-30 minute reliable advance notice of onset of fog at an airport (i. e., airport goes below minimums)
8. 15-30 minute reliable advance notice of fog lifting at an airport
9. Reliable estimate of length of time airport will be below minimums

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight Problem to me?
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Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

CLOUDS, VISIBILITY, FOG

10. 15-30 minute advance notice of arrival and departure of VFR conditions
11. Visibility, cloud cover, and ceiling at airports where no observations are presently made

ADDITIONAL SUGGESTIONS

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight Problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

RUNWAY

1. The amount and location of ice and slush on the runway
2. Braking conditions of runway by segments (e.g., first 1/3, middle 1/3, last 1/3)
3. When conditions are conducive to hydroplaning for various types of aircraft
4. Faster method of clearing runway and keeping it clear
5. Temperature at ends of runway

ADDITIONAL SUGGESTIONS

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight Problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

OTHERS

1. 15-30 minutes advance notice of freezing rain or heavy snow at an airport (icing of parked aircraft)
2. Altitude at which snow changes to rain
3. Accurate temperature by altitude in vicinity of airport
4. Temperature inversion in approach or climb-out zones
5. Areas where icing conditions exist and type of icing (rime or clear)
6. Reports from automatic weather stations at key locations in the mountains
7. Automatic transcribing and transmitting of all pilot reports, Sigmets, and Airmets to aircraft in the vicinity, within 15 minutes of the time the report is made
8. Rapid updating of weather data at satellite airports

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight problem to me?

Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

ADDITIONAL SUGGESTIONS

FORECASTS

We are not attempting here to criticize present forecasting techniques, accuracy, etc. What we would like to know is what type of forecasts you need, how you will use them, and what forecast accuracy is required so that the forecast will significantly influence your decision-making process. Obviously, 100% forecasting accuracy is wanted by everyone. Even more obvious is that it is unachievable. In a practical sense, it is clear that the longer in advance the forecast is, the less accurate it will be. In presenting the questions in the format below, we are attempting to discover what types of forecasts hold the greatest potential for improved decision making.

FORECASTS

1. Forecast of freezing rain, hail, or heavy snow at airport
2. Forecast of other severe weather such as squall line, thunderstorm, hurricane, or tornado in vicinity of airport
3. Forecast of onset of fog (i. e., airport going below minimums)
4. Forecast of duration of fog and/or time when airport goes above minimums.
5. Cloud cover, precipitation, and visibility forecast at airport

What decision(s) that you make would be influenced by this forecast? Additional comments?	How long of an advanced forecast is needed?	The forecast must be essentially accurate what percent of the time to be influential in your decision making?

FORECASTS

5. Forecast of wind shear in approach or climb-out zones
7. Forecasts of regions where icing conditions exist and type of icing (rime or clear)
9. Forecast of speed and direction of frontal movement
9. Forecast of low level winds (0-10,000 ft.)
0. Forecasts of mountain wave activity
1. Forecast of turbulence in approach and climb-out zones
2. Forecast of wind shear associated with frontal activity, temperature inversion, sea breeze, etc.
3. More rapid updating of forecasts when conditions change

OTHER FORECASTS (Specify)

	What decision(s) that you make would be influenced by this forecast? Additional comments?	How long of an advanced forecast is needed?	The forecast must be essentially accurate what percent of the time to be influential in your decision making?

INSTRUMENTATION

Tower Control

1. A network of sensors in vicinity of airport to provide real time observations of approaching weather conditions

2. Instrumentation that would provide a convenient means of accumulating, displaying, and updating all available weather in immediate vicinity of airport

3. Instrumentation used to automatically notify incoming aircraft of changes in significant weather conditions as they occur at airport; e.g., wind shear, thunderstorm or runway condition

4. Sensor to measure type and intensity of wind shear in vicinity of runway

5. Sensor to measure wake turbulence in vicinity of runway

6. Ground sensor to measure turbulence in approach and climb-out zones

7. Instrument to measure thickness of fog layer over airport

Would this sensor be of use to you? (Yes/No)	Would it provide the data needed to solve one of your (1) serious, (2) moderate, (3) slight problem.	What are the requirements for the sensor to be useful; e.g., cost, size, reliability? (Specify values if possible)	Comment about how the sensor would influence your performance
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ADDITIONAL SUGGESTIONS

INSTRUMENTATION

Approach Control

1. An instrument that pictorially displays the type of weather information requested
2. Instrumentation that would automatically notify a pilot of his encroachment upon severe weather
3. A means of distinguishing heavy rain from hail on traffic controller's radar
4. Improvement of traffic controller's radar so that fog and temperature inversions do not appear as areas of precipitation
5. Ability to tell altitude of thunderstorm with traffic control radar
6. Ability to tune into weather radar

ADDITIONAL SUGGESTIONS

Would this sensor be of use to you? (Yes/No)	Would it provide the data needed to solve one of your (1) serious, (2) moderate, (3) slight problem	What are the requirements for the sensor to be useful; e.g., cost, size, reliability? (Specify values if possible)	Comment about how the sensor would influence your performance
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EN ROUTE CONTROLLERS

EN ROUTE CONTROLLERS

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Thank you for your cooperation.

James K. Luers

University of Dayton
Research Institute
(513) 229-3921

BIOGRAPHY

In analyzing your response to this questionnaire, some background information is necessary. This information will be useful to us in analyzing the results from this questionnaire. We request you give your name and telephone number so we can get in contact with you should any clarification be necessary. Please indicate if you would like to receive a copy of the report resulting from this study and whether or not you object to your name appearing in such a report.

NAME _____

ADDRESS _____

TELEPHONE _____

TRAINING _____

EXPERIENCE AS ENROUTE CONTROLLER _____ YEARS

RADAR EXPERIENCE YEARS

Conventional Traffic Control Radar _____

Digital Traffic Control Radar _____

Weather Radar _____

PILOT'S LICENSE(S) _____

FLYING EXPERIENCE

Type Aircraft	Flying Hours
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Jet	_____
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Prop	_____
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Helicopter	_____
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Would you like to receive a copy of the report resulting from this study? _____

Can your name be included in such a report? _____

THUNDERSTORM ACTIVITY

1. The location of turbulence within and around a thunderstorm

2. The tops of the clouds above a thunderstorm cell

3. The areas of icing within a thunderstorm

4. The ability to distinguish between heavy rain and hail by radar

5. An up-to-the-minute account of present thunderstorm activity; its direction, speed, and severity.

6. A 15-30 minute advance projection of incoming thunderstorm activity

ADDITIONAL SUGGESTIONS

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate or (3) Slight problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

TURBULENCE AND WIND

1. Precise location of clear air turbulence along an air route

2. Location of wake turbulence along air routes

3. Location of and wind speed in jet stream

4. Upper air winds (above 10,000 ft.) by altitude along any air route

5. Low level wind (below 10,000 ft.) by altitude for a specified area

6. Surface winds at various locations in the mountains (e.g., passes, along ridges)

7. Location and intensity of mountain wave turbulence

8. Winds and altimeter setting at satellite airports where no observations are presently made

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, or (3) Slight Problem to me?

Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

ADDITIONAL SUGGESTIONS

CLOUDS, VISIBILITY, FOG

1. Cloud base along an air route for a given area or in vicinity of an airport
2. Tops of each layer of clouds along an air route for a given area or in vicinity of airport
3. Visibility in area where snow is occurring (i.e., degradation of visibility resulting from snow)
4. Location and height of haze (pollution) layer
5. Enroute visibility along an air route or for a specified region
6. 15-30 minute reliable advance notice of onset of fog at an airport; i.e., airport goes below minimums
7. 15-30 minute reliable advance notice of fog lifting at an airport
8. Reliable estimate of length of time airport will be below minimums
9. 15-30 minute advance notice of arrival and departure of VFR conditions

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

CLOUDS, VISIBILITY, FOG

10. Cloud base at various locations in mountains (e.g., passes, ridges, etc.)
11. Visibility, cloud cover, and ceiling at airports where no observations are presently made

ADDITIONAL SUGGESTIONS

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate or (3) Slight problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

OTHERS

1. Availability of present weather conditions for any region of the country; e.g., thunderstorm activity, hail, visibility, cloud cover, etc.
2. Accurate temperature at any altitude along an air route
3. Areas where icing conditions exist and type of icing (rime or clear)
4. Altitude at which snow changes to rain
5. Automatic transcribing and transmitting of all pilot reports, Sigmets, and Airmets to aircraft in the vicinity, within 15 minutes of the time the report is made
6. Reports from automatic weather stations at key locations in the mountains
7. Rapid updating of weather data at satellite airports

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight Problem to me?	Describe <u>when</u> and <u>how</u> you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

ADDITIONAL SUGGESTIONS

FORECASTS

We are not attempting here to criticize present forecasting techniques, accuracy, etc. What we would like to know is what type of forecasts you need, how you will use them, and what forecast accuracy is required so that the forecast will significantly influence a decision-making process. Obviously, 100% forecasting accuracy is wanted by everyone. Even more obvious is that it is unachievable. In a practical sense, it is clear that the longer in advance the forecast is, the less accurate it will be. In presenting the questions in the format below, we are attempting to discover what types of forecasts hold the greatest potential for improved decision making.

FORECASTS

1. Forecast of freezing rain, hail, or heavy snow in vicinity of an airport
2. Forecasts of other severe weather such as thunderstorms, squall lines, tornadoes and hurricanes
3. Forecast of onset of fog (i.e., airport going below minimums)
4. Forecast of duration of fog and/or time when airport goes above minimums
5. Forecasts of cloud cover, precipitation and visibility

	<p>What decision(s) that you make would be influenced by this forecast? Additional comments?</p>	How long of an advanced forecast is needed?	The forecast must be essentially accurate what percent of the time to be influential in your decision making?
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FORECASTS

6. Forecast of regions where icing conditions exist and type of icing (rime or clear)
7. Forecast of speed and direction of frontal movement
8. Clear air and other types of turbulence forecasts by region and altitude
9. Forecast of upper air temperatures by region and altitude
10. Jet stream forecast (its location and speed)
11. Forecast of upper air winds (>10,000 ft.)
12. Forecast of low level winds (0-10,000 ft.)
13. Forecast of mountain wave activity
14. More rapid updating of forecasts when conditions change

OTHERS (Specify)

What decision(s) that you make would be influenced by this forecast?
Additional comments?

How long of an advanced forecast is needed?

The forecast must be essentially accurate what percent of the time to be influential in your decision making?

INSTRUMENTATION

1. An instrument that pictorially displays the type of weather information requested
2. Instrumentation that would automatically notify a pilot of his encroachment upon severe weather
3. A means of distinguishing heavy rain from hail on traffic controller's radar
4. Improvement of traffic controller's radar so that fog and temperature inversions do not appear as areas of precipitation
5. Ability to tell altitude of thunder-storm with traffic control radar
6. Ability to tune in weather radar

Would this sensor be of use to you? (Yes/No)	Would it provide the data needed to solve one of your (1) serious, (2) moderate, (3) slight problems?	What are the requirements for the sensor to be useful; e.g., cost, size, reliability? (Specify values if possible)	Comment about how the sensor would influence your performance

ADDITIONAL SUGGESTIONS

FLIGHT SERVICE STATION PERSONNEL

FLIGHT SERVICE STATION PERSONNEL

The National Aeronautics and Space Administration (NASA) and its predecessor, the National Advisory Committee for Aeronautics (NACA) has long served as the U.S. governments' primary source of advanced technology for aeronautical and space activities. Present aeronautical research activities of NASA include a broad program of new technology development to enhance aviation safety. Included in this program are several individual research projects related to the meteorological aspects of aviation safety. These projects explore advanced measurement and analysis concepts which offer the potential for improved design optimization of aircraft, control systems, ground and airborne instrumentation and their sensors, by NOAA, NWS, FAA, and the commercial manufacturers. To assist NASA in conducting research that is responsive to the most pressing needs for new technology the University of Dayton Research Institute (UDRI) is conducting a study for NASA intended to provide a better focus on future technology needs in this area. The enclosed questionnaire has been carefully developed with assistance from FAA, NOAA, and NTSB and is intended solely to define required technology improvements; not to be a critical evaluation of present meteorological information collection and dissemination procedures. Candid suggestions that could potentially result in improved aviation safety through the development of new natural environment technology are welcomed.

The UDRI is soliciting and reviewing relevant ideas from a wide spectrum of the aviation community: airline, charter, corporate, and private pilots; en route, approach, and tower controllers; airline meteorologists; FSS personnel; and professional associations.

The attached list of questions was generated through discussions with people from a wide cross section of the aeronautical community including pilots, FAA personnel, NWS personnel and meteorologists. In responding to these questions, we would ask that you specify the

reason for your answer and the use to which you would put the data. Since a statistical compilation of the results is NOT the objective of this questionnaire, the mere frequency of a given response is of little importance. Rather, what is important is a discussion of the use and need of each type of information so that its importance relative to aviation safety and performance can be evaluated. We ask you to keep in mind that aviation accidents are often associated with severe or unusual weather conditions. Though the frequency of occurrence of these events may be seldom, the potential for improved aviation safety under these conditions could be significant if appropriate technology were available.

In responding to this questionnaire, we ask that you answer the questions in relation to how it affects you without speculation concerning the desires of other persons involved (such as pilots, traffic controllers, etc.). Similar questionnaires are being sent to other members of the aviation community. Each topic within the questionnaire is concluded with a blank space for additional comments. We welcome here any further discussions of problems which you feel were inadequately presented, or perhaps other ideas or concepts that you feel are pertinent.

A follow-up telephone interview will be made with selected respondents of this questionnaire. The purpose of the follow-up will be to solicit additional information and/or clarification concerning responses that are deemed especially noteworthy. For this reason, we request you sign your name, give your telephone number and a brief description of your experience. No individual names of respondents will be included in any published document without the consent of the individual.

Thank you for your cooperation.

James K. Luers

University of Dayton
Research Institute
(513) 229-3921

BIOGRAPHY

In analyzing your response to this questionnaire, some background information is necessary. This information will be useful to us in analyzing the results from this questionnaire. We request you give your name and telephone number so we can get in contact with you should any clarification be necessary. Please indicate if you would like to receive a copy of the report resulting from this study and whether or not you object to your name appearing in such a report.

NAME _____

ADDRESS _____

TELEPHONE _____

TRAINING _____

FLIGHT SERVICE STATION EXPERIENCE _____ YEARS

RADAR EXPERIENCE YEARS

(Specify types of radar; e.g., weather radar, ground control, etc.)

PILOT'S LICENSE(S) _____

FLYING EXPERIENCE

Type Aircraft Flying Hours

Jet _____

Prop _____

Helicopter _____

Would you like to receive a copy of the report resulting from this study? _____

Can your name be included in such a report? _____

THUNDERSTORMS ACTIVITY

1. The location of turbulence within and around a thunderstorm

2. The tops of the clouds above a thunderstorm cell

3. The areas of icing within a thunder-storm

4. An up-to-the-minute account of present thunderstorm activity along an air route, its direction, speed, and severity

5. A 15-30 minute advance projection of thunderstorm activity for any area

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate or (3) Slight problem to me?

Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

ADDITIONAL SUGGESTIONS

TURBULENCE AND WIND

1. Precise location of clear air turbulence in an area
2. Location and severity of wind shear in vicinity of an airport
3. Location of and wind speed in jet stream
4. Upper air winds (above 10,000 ft.) by altitude for a specified area
5. Low level winds (below 10,000 ft.) by altitude for a specified area
6. Surface winds at various locations in the mountains (e.g., along ridges)
7. Location and intensity of mountain wave turbulence
8. Winds and altimeter setting at satellite airports where no observations are taken

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

ADDITIONAL SUGGESTIONS

CLOUDS, VISIBILITY, FOG

1. Cloud base along an air route, for a given area, or in vicinity of airport
2. Tops of each layer of clouds along an air route, for a given area or in vicinity of airport
3. Enroute visibility along an air route or for a specified region
4. Visibility in area where snow is occurring (degradation of visibility resulting from snow)
5. Cloud base at various locations in mountains, e.g., passes, ridges, etc.
6. Location and height of haze (pollution) layer
7. Slant Visual Range (SVR) along the glide slope
8. 15-30 minute reliable advance notice of onset of fog at an airport; i.e., airport goes below minimums
9. 15-30 minute reliable advance notice of fog lifting at an airport

Is this information relevant? - (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight problem to me?

Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

CLOUDS, VISIBILITY, FOG

10. Reliable estimate of length of time airport will be below minimums
11. 15-30 minute advance notice of arrival and departure of VFR conditions
12. Visibility, cloud cover, and ceiling at airports where no observations are presently made

ADDITIONAL SUGGESTIONS

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight problem to me?	Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

OTHERS

1. 15-30 minutes advance notice of freezing rain or heavy snow at an airport (icing of parked aircraft)
2. Altitude at which snow changes to rain in a given area
3. Accurate temperature at any altitude along an air route or for a specified area
4. Areas where icing conditions exist and the type of icing (rime or clear)
5. Immediate availability of up-to-the-minute weather conditions for any region of the country
6. Immediate availability of up-to-the-minute weather radar maps for any region of the country
7. Immediate access to pilot-reports for any region of the country
8. Adequacy of NWS Surface Weather Maps relative to your needs

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate or (3) Slight Problem to me?

Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

OTHERS

9. More frequent update of NWS maps and forecasts
10. Detailed satellite derived charts depicting cloud cover, cloud tops and cloud layers for any region of the country

ADDITIONAL SUGGESTIONS

Is this information relevant? (Yes/No)	Is this information presently available to me in sufficient detail and accuracy? (Yes/No)	Does lack of this information rate as (1) Serious, (2) Moderate, (3) Slight problem to me?	

Describe when and how you would use this information if it were available to you (please comment on all serious problems and others as appropriate).

FORECASTS

We are not attempting here to criticize present forecasting techniques, accuracy, etc. What we would like to know is what type of forecasts you need, how you will use them, and what forecast accuracy is required so that the forecast will significantly influence your decision-making process. Obviously, 100% forecasting accuracy is wanted by everyone. Even more obvious is that it is unachievable. In a practical sense, it is clear that the longer in advance the forecast is, the less accurate it will be. In presenting the questions in the format below, we are attempting to discover what types of forecasts hold the greatest potential for improved decision making.

FORECASTS

1. Forecast of onset and termination of freezing rain and heavy snow at airport
2. Forecast of onset of fog (i.e., airport going below minimums)
3. Forecast of duration of fog and/or time when airport goes above minimums
4. Cloud cover, precipitation, visibility forecast at an airport

	<p>What decision(s) that you make would be influenced by this forecast? Additional comments?</p>	How long of an advanced forecast is needed?	The forecast must be essentially accurate what percent of the time to be influential in your decision making?
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FORECASTS

- 5. Forecasts of regions of clear air and other types of turbulence**
- 6. Forecasts of wind shear at an airport**
- 7. Forecast of upper air temperatures by region and altitude**
- 8. Forecasts of regions where icing conditions exist**
- 9. Forecast of type of icing (rime or clear)**
- 10. Forecasts of severe enroute weather**
- 11. Forecasts of upper air winds
 $>10,000$ ft.**
- 12. Forecasts of low level winds
 $<10,000$ ft.**
- 13. Jet stream forecast (its location and speed)**
- 14. Forecasts of visibility in mountains**

What decision(s) that you make would be influenced by this forecast?

Additional comments?

How long of an advanced forecast is needed?

The forecast must be essentially accurate what percent of the time to be influential in your decision making?

FORECASTS

- 15. Forecasts of mountain wave activity**
- 16. More rapid updating of forecasts when conditions change**

ADDITIONAL SUGGESTIONS

What decision(s) that you make would be influenced by this forecast?
Additional comments?

How long of an advanced forecast is needed?

The forecast must be essentially accurate what percent of the time to be influential in your decision making?

INSTRUMENTATION

1. Instrument to measure thickness of fog layer over airport

2. Instrument to pictorially display weather information at FSS

3. Instrumentation that would provide to FSS a convenient means of accumulating, displaying, and updating all available weather for any region desired

4. Automatic remote weather observations in mountains

5. Automatic remote weather observation at satellite airports where no observations are presently made

6. Instrumentation for automatic processing and retransmitting of pilot reports to all aircraft in vicinity

ADDITIONAL SUGGESTIONS

	Would this sensor be of use to you? (Yes/No)	Would it provide the data needed to solve one of your (1) serious, (2) moderate, (3) slight problems	What are the requirements for the sensor to be useful; e.g., cost, size, reliability? (Specify values if possible)	Comment about how the sensor would influence your performance
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